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Fibre Channel Routing Information MIB

Status of This Memo

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Abstract

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes managed objects for information related to routing within a Fibre Channel fabric, which is independent of the usage of a particular routing protocol.

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1. Introduction

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes managed objects for information related to the Fibre Channel network's Routing Table for routing within a Fabric. Managed objects specific to particular routing protocols, such as the Fabric Shortest Path First (FSPF) protocol [FC-SW-4], are not specified in this MIB module.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIv2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

3. Short Overview of Fibre Channel

3.1. Introduction

The Fibre Channel (FC) is logically a bidirectional point-to-point serial data channel, structured for high performance. Fibre Channel provides a general transport vehicle for higher-level protocols, such as Small Computer System Interface (SCSI) command sets, the High-Performance Parallel Interface (HIPPI) data framing, IP (Internet Protocol), IEEE 802.2, and others.

Physically, Fibre Channel is an interconnection of multiple communication points, called N_Ports, interconnected either by a switching network, called a Fabric, or by a point-to-point link. A Fibre Channel "node" consists of one or more N_Ports. A Fabric may consist of multiple Interconnect Elements, some of which are switches. An N_Port connects to the Fabric via a port on a switch called an F_Port. When multiple FC nodes are connected to a single port on a switch via an "Arbitrated Loop" topology, the switch port

is called an FL_Port, and the nodes' ports are called NL_Ports. The term Nx_Port is used to refer to either an N_Port or an NL_Port. The term Fx_Port is used to refer to either an F_Port or an FL_Port. A switch port, which is interconnected to another switch port via an Inter-Switch Link (ISL), is called an E_Port. A B_Port connects a bridge device with an E_Port on a switch; a B_Port provides a subset of E_Port functionality.

Many Fibre Channel components, including the fabric, each node, and most ports, have globally-unique names. These globally-unique names are typically formatted as World Wide Names (WWNs). More information on WWNs can be found in [FC-FS]. WWNs are expected to be persistent across agent and unit resets.

Fibre Channel frames contain 24-bit address identifiers that identify the frame's source and destination ports. Each FC port has both an address identifier and a WWN. When a fabric is in use, the FC address identifiers are dynamic and are assigned by a switch. Each octet of a 24-bit address represents a level in an address hierarchy, a Domain_ID being the highest level of the hierarchy.

3.2. Routing Protocols

The routing of frames within the Fabric is normally based on the standard routing protocol, called the Fabric Shortest Path First (FSPF) protocol. The operation of FSPF (or of any other routing protocol) allows a switch to generate and maintain its own routing table of how to forward frames it receives; i.e., a table in which to look up the destination address of a received frame in order to determine the best link by which to forward that frame towards its destination.

3.3. Virtual Fabrics

The latest standard for an interconnecting Fabric containing multiple Fabric Switch elements is [FC-SW-4] (which replaces the previous revision, [FC-SW-3]). [FC-SW-4] carries forward the existing specification for the operation of a single Fabric in a physical infrastructure, augmenting it with the definition of Virtual Fabrics and with the specification of how multiple Virtual Fabrics can operate within one (or more) physical infrastructures. The use of Virtual Fabrics provides for each frame to be tagged in its header to indicate which one of several Virtual Fabrics that frame is being transmitted on. All frames entering a particular "Core Switch" [FC-SW-4] (i.e., a physical switch) on the same Virtual Fabric are processed by the same "Virtual Switch" within that Core switch.

4. Relationship to Other MIBs

The first standardized MIB for Fibre Channel [RFC2837] was focussed on Fibre Channel switches. It is being replaced by the more generic Fibre Channel Management MIB [FC-MGMT], which defines basic information for Fibre Channel hosts and switches, including extensions to the standard IF-MIB [RFC2863] for Fibre Channel interfaces.

This MIB extends beyond [FC-MGMT] to cover the routing of traffic within a Fabric of a Fibre Channel network. The standard routing protocol for Fibre Channel is FSPF [FC-SW-4]. Another MIB [RFC4626] specifies management information specific to FSPF. This MIB contains routing information that is independent of FSPF (i.e., it would still apply even if a routing protocol other than FSPF were in use in the network).

This MIB imports some common Textual Conventions from T11-TC-MIB, defined in [RFC4439].

5. MIB Overview

This MIB module provides the means for monitoring the operation of, and configuring some parameters of, one or more instances of the FSPF protocol. (Note that there are no definitions in this MIB module of "managed actions" that can be invoked via SNMP.)

5.1. Fibre Channel Management Instance

A Fibre Channel management instance is defined in [FC-MGMT] as a separable managed instance of Fibre Channel functionality. Fibre Channel functionality may be grouped into Fibre Channel management instances in whatever way is most convenient for the implementation(s). For example, one such grouping accommodates a single SNMP agent with multiple AgentX [RFC2741] sub-agents, each sub-agent implementing a different Fibre Channel management instance.

The object, fcmInstanceIndex, is IMPORTed from the FC-MGMT-MIB [FC-MGMT] as the index value that uniquely identifies each Fibre Channel management instance within the same SNMP context ([RFC3411], Section 3.3.1).

5.2. Switch Index

The FC-MGMT-MIB [FC-MGMT] defines the fcmSwitchTable as a table of information about Fibre Channel switches that are managed by Fibre Channel management instances. Each Fibre Channel management instance can manage one or more Fibre Channel switches. The Switch Index, fcmSwitchIndex, is IMPORTed from the FC-MGMT-MIB as the index value that uniquely identifies a Fibre Channel switch among those (one or more) managed by the same Fibre Channel management instance.

5.3. Fabric Index

Whether operating on a physical Fabric (i.e., without Virtual Fabrics) or within a Virtual Fabric, the operation of FSPF within a Fabric is identical. Therefore, this MIB defines all Fabric-related information in tables that are INDEX-ed by an arbitrary integer, named a "Fabric Index", the syntax of which is IMPORTed from the T11-TC-MIB. When a device is connected to a single physical Fabric, without use of any virtual Fabrics, the value of this Fabric Index will always be 1. In an environment of multiple virtual and/or physical Fabrics, this index provides a means to distinguish one Fabric from another.

It is quite possible, and may even be likely, that a Fibre Channel switch will have ports connected to multiple virtual and/or physical Fabrics. Thus, in order to simplify a management protocol query concerning all the Fabrics to which a single switch is connected, fcmSwitchIndex will be listed before t11FcRouteFabricIndex when they both appear in the same INDEX clause.

5.4. The t11FcRouteGroup Group

This MIB contains one object group, the t11FcRouteGroup, which contains objects to allow the displaying and the configuring of routes in the Fibre Channel Routing tables for the locally managed switches.

5.5. The t11FcRouteTable's INDEX

It is normally valuable for a MIB table that contains routes to be ordered such that a management application is able to query the table based on some attribute, without having to read every row in the MIB table. This requires that the rows in the table be ordered according to such attributes, and thus that those attributes be represented by objects included in the table's INDEX clause. Examples of this can be seen in the ipCidrRouteTable [RFC2096] and, more recently, the inetCidrRouteTable in [RFC4292].

While this useful feature results in an unusually large number (ten) of objects in the t11FcRouteTable's INDEX clause, all ten are either integers or strings of 3 (or zero) octet length, so the resulting OIDs are not unusually large. (Specifically, the aggregate number of sub-identifiers to be appended to an OBJECT-TYPE's OID, when naming an instance of an object in the t11FcRouteTable, is at most 22 sub-identifiers; i.e., less than the *minimum* number to be appended for the inetCidrRouteTable table.)

6. The T11-FC-ROUTE-MIB Module

```
T11-FC-ROUTE-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE,
    Unsigned32, mib-2                    FROM SNMPv2-SMI  -- [RFC2578]
    MODULE-COMPLIANCE, OBJECT-GROUP      FROM SNMPv2-CONF -- [RFC2580]
    RowStatus, TimeStamp,
    StorageType                          FROM SNMPv2-TC   -- [RFC2579]
    InterfaceIndex, InterfaceIndexOrZero  FROM IF-MIB     -- [RFC2863]
    fcmInstanceIndex, fcmSwitchIndex,
    FcAddressIdOrZero, FcDomainIdOrZero FROM FC-MGMT-MIB -- [FC-MGMT]
    T11FabricIndex                       FROM T11-TC-MIB; -- [RFC4439]

t11FcRouteMIB MODULE-IDENTITY
    LAST-UPDATED "200608140000Z"
    ORGANIZATION "T11"
    CONTACT-INFO
              "     Claudio DeSanti
                    Cisco Systems, Inc.
                    170 West Tasman Drive
                    San Jose, CA 95134 USA
                    EMail: cds@cisco.com


                    Keith McCloghrie
                    Cisco Systems, Inc.
                    170 West Tasman Drive
                    San Jose, CA USA 95134
                    Email: kzm@cisco.com"
    DESCRIPTION
           "The MIB module for configuring and displaying Fibre
           Channel Route Information.

           Copyright (C) The Internet Society (2006).  This version
           of this MIB module is part of RFC 4625;  see the RFC
           itself for full legal notices."
    REVISION     "200608140000Z"
```

```
    DESCRIPTION
           "Initial version of this MIB module, published as RFC4625."

    ::= {mib-2 144 }

t11FcRouteNotifications OBJECT IDENTIFIER ::= { t11FcRouteMIB 0 }
t11FcRouteObjects       OBJECT IDENTIFIER ::= { t11FcRouteMIB 1 }
t11FcRouteConformance   OBJECT IDENTIFIER ::= { t11FcRouteMIB 2 }

--
-- Per-Fabric routing information
--
t11FcRouteFabricTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF T11FcRouteFabricEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The table containing Fibre Channel Routing information
           that is specific to a Fabric."
    ::= { t11FcRouteObjects 1 }

t11FcRouteFabricEntry OBJECT-TYPE
    SYNTAX      T11FcRouteFabricEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "Each entry contains routing information specific to a
           particular Fabric on a particular switch (identified by
           values of fcmInstanceIndex and fcmSwitchIndex)."
    INDEX      { fcmInstanceIndex, fcmSwitchIndex,
                 t11FcRouteFabricIndex }
    ::= { t11FcRouteFabricTable 1 }

T11FcRouteFabricEntry ::=
    SEQUENCE {
        t11FcRouteFabricIndex      T11FabricIndex,
        t11FcRouteFabricLastChange TimeStamp
    }

t11FcRouteFabricIndex OBJECT-TYPE
    SYNTAX      T11FabricIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "A unique index value that uniquely identifies a
           particular Fabric.

           In a Fabric conformant to FC-SW-3, only a single Fabric
```

```
            can operate within a physical infrastructure, and thus
            the value of this Fabric Index will always be 1.

            In a Fabric conformant to FC-SW-4, multiple Virtual Fabrics
            can operate within one (or more) physical infrastructures.
            In such a case, index value is used to uniquely identify a
            particular Fabric within a physical infrastructure."
    ::= { t11FcRouteFabricEntry 1 }

t11FcRouteFabricLastChange OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The value of sysUpTime at the most recent time when any
            corresponding row in the t11FcRouteTable was created,
            modified, or deleted.  A corresponding row in the
            t11FcRouteTable is for the same management instance,
            the same switch, and same Fabric as the row in this table.

            If no change has occurred since the last restart of the
            management system, then the value of this object is 0."
    ::= { t11FcRouteFabricEntry 2 }

--
-- Fibre Channel Routing table
--
t11FcRouteTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF T11FcRouteEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The Fibre Channel Routing tables for the
            locally managed switches.  This table lists all the
            routes that are configured in and/or computed by any
            local switch for any Fabric.

            Such routes are used by a switch to forward frames (of user
            data) on a Fabric.  The conceptual process is based on
            extracting the Destination Fibre Channel Address Identifier
            (D_ID) out of a received frame (of user data) and comparing
            it to each entry of this table that is applicable to the
            given switch and Fabric.  Such comparison consists of first
            performing a logical-AND of the extracted D_ID with a mask
            (the value of t11FcRouteDestMask) and second comparing the
            result of that 'AND' operation to the value of
            t11FcRouteDestAddrId.  A similar comparison is made of the
            Source Fibre Channel Address Identifier (S_ID) of a frame
```

```
            against the t11FcRouteSrcAddrId and t11FcRouteSrcMask values
            of an entry.  If an entry's value of t11FcRouteInInterface
            is non-zero, then a further comparison determines if the
            frame was received on the appropriate interface.  If all of
            these comparisons for a particular entry are successful,
            then that entry represents a potential route for forwarding
            the received frame.

            For entries configured by a user, t11FcRouteProto has
            the value 'netmgmt'; only entries of this type can be
            deleted by the user."
    ::= { t11FcRouteObjects 2 }

t11FcRouteEntry OBJECT-TYPE
    SYNTAX      T11FcRouteEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Each entry contains a route to a particular destination,
            possibly from a particular subset of source addresses,
            on a particular Fabric via a particular output interface
            and learned in a particular manner."
    INDEX       { fcmInstanceIndex, fcmSwitchIndex,
                  t11FcRouteFabricIndex,
                  t11FcRouteDestAddrId, t11FcRouteDestMask,
                  t11FcRouteSrcAddrId, t11FcRouteSrcMask,
                  t11FcRouteInInterface, t11FcRouteProto,
                  t11FcRouteOutInterface }
    ::= { t11FcRouteTable 1 }
T11FcRouteEntry ::=
    SEQUENCE {
        t11FcRouteDestAddrId   FcAddressIdOrZero,
        t11FcRouteDestMask     FcAddressIdOrZero,
        t11FcRouteSrcAddrId    FcAddressIdOrZero,
        t11FcRouteSrcMask      FcAddressIdOrZero,
        t11FcRouteInInterface  InterfaceIndexOrZero,
        t11FcRouteProto        INTEGER,
        t11FcRouteOutInterface InterfaceIndex,
        t11FcRouteDomainId     FcDomainIdOrZero,
        t11FcRouteMetric       Unsigned32,
        t11FcRouteType         INTEGER,
        t11FcRouteIfDown       INTEGER,
        t11FcRouteStorageType  StorageType,
        t11FcRouteRowStatus    RowStatus
    }

t11FcRouteDestAddrId OBJECT-TYPE
    SYNTAX      FcAddressIdOrZero (SIZE (3))
```

```
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The destination Fibre Channel Address Identifier of
           this route.  A zero-length string for this field is
           not allowed."
    ::= { t11FcRouteEntry 1 }

t11FcRouteDestMask OBJECT-TYPE
    SYNTAX      FcAddressIdOrZero
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The mask to be logical-ANDed with a destination
           Fibre Channel Address Identifier before it is compared
           to the value in the t11FcRouteDestAddrId field.
           Allowed values are 255.255.255, 255.255.0, or 255.0.0.
           FSPF's definition generates routes to a Domain_ID,
           so the mask for all FSPF-generated routes is 255.0.0.
           The zero-length value has the same meaning as 0.0.0."
    ::= { t11FcRouteEntry 2 }

t11FcRouteSrcAddrId OBJECT-TYPE
    SYNTAX      FcAddressIdOrZero
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The source Fibre Channel Address Identifier of this
           route.  Note that if this object and the corresponding
           instance of t11FcRouteSrcMask both have a value of 0.0.0,
           then this route matches all source addresses.  The
           zero-length value has the same meaning as 0.0.0."
    ::= { t11FcRouteEntry 3 }

t11FcRouteSrcMask OBJECT-TYPE
    SYNTAX      FcAddressIdOrZero
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The mask to be logical-ANDed with a source
           Fibre Channel Address Identifier before it is compared
           to the value in the t11FcRouteSrcAddrId field.  Allowed
           values are 255.255.255, 255.255.0, 255.0.0, or 0.0.0.
           The zero-length value has the same meaning as 0.0.0."
    ::= { t11FcRouteEntry 4 }

t11FcRouteInInterface OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
```

```
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "If the value of this object is non-zero, it is the
           value of ifIndex that identifies the local
           Fibre Channel interface through which a frame
           must have been received in order to match with
           this entry.  If the value of this object is zero,
           the matching does not require that the frame be
           received on any specific interface."
    ::= { t11FcRouteEntry 5 }

t11FcRouteProto OBJECT-TYPE
    SYNTAX   INTEGER {
                other(1),
                local(2),
                netmgmt(3),
                fspf(4)
             }
    MAX-ACCESS not-accessible
    STATUS   current
    DESCRIPTION
           "The mechanism via which this route was learned:
                other(1)  - not specified
                local(2)  - local interface
                netmgmt(3)- static route
                fspf(4)   - Fibre Shortest Path First
           "
    ::= { t11FcRouteEntry 6 }

t11FcRouteOutInterface OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
           "The value of ifIndex that identifies the local
           Fibre Channel interface through which the next hop
           of this route is to be reached."
    ::= { t11FcRouteEntry 7 }

t11FcRouteDomainId OBJECT-TYPE
    SYNTAX      FcDomainIdOrZero
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
           "The domain_ID of next hop switch.

           This object can have a value of zero if the value
```

```
            of t11FcRouteProto is 'local'."
    ::= { t11FcRouteEntry 8 }

t11FcRouteMetric OBJECT-TYPE
    SYNTAX      Unsigned32 (0..65536)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
            "The routing metric for this route.

            The use of this object is dependent on t11FcRouteProto."
    ::= { t11FcRouteEntry 9 }

t11FcRouteType OBJECT-TYPE
    SYNTAX      INTEGER {
                    local(1),
                    remote(2)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
            "The type of route.

            local(1)  - a route for which the next Fibre Channel
                        port is the final destination;
            remote(2) - a route for which the next Fibre Channel
                        port is not the final destination."
    DEFVAL {local}
    ::= { t11FcRouteEntry 10 }

t11FcRouteIfDown OBJECT-TYPE
    SYNTAX      INTEGER {
                    remove(1),
                    retain(2)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
            "The value of this object indicates what happens to
            this route when the output interface (given by the
            corresponding value of t11FcRouteOutInterface) is
            operationally 'down'.  If this object's value is 'retain',
            the route is to be retained in this table.  If this
            object's value is 'remove', the route is to be removed
            from this table."
    DEFVAL  { retain }
    ::= { t11FcRouteEntry 11 }
```

```
t11FcRouteStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
           "The storage type for this conceptual row.
           Conceptual rows having the value 'permanent' need not
           allow write-access to any columnar objects in the row."
       DEFVAL { nonVolatile }
    ::= { t11FcRouteEntry 12 }

t11FcRouteRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
           "The status of this conceptual row.
           The only rows that can be deleted by setting this object to
           'destroy' are those for which t11FcRouteProto has the value
           'netmgmt'."
    ::= { t11FcRouteEntry 13 }

--
-- Conformance
--
t11FcRouteCompliances OBJECT IDENTIFIER
                         ::= { t11FcRouteConformance 1 }
t11FcRouteGroups      OBJECT IDENTIFIER
                         ::= { t11FcRouteConformance 2 }


t11FcRouteCompliance  MODULE-COMPLIANCE
    STATUS    current
    DESCRIPTION
           "The compliance statement for entities that
           implement the T11-FC-ROUTE-MIB.
--
-- Note: The next four OBJECT clauses are for auxiliary objects, and the
-- SMIv2 does not permit inclusion of objects that are not accessible
-- in an OBJECT clause (see Sections 3.1 & 5.4.3 in STD 58, RFC 2580).
-- Thus, these four clauses cannot be included below in the normal
-- location for OBJECT clauses.
--
--      OBJECT     t11FcRouteSrcAddrId
--      SYNTAX     FcAddressIdOrZero (SIZE (0))
--      DESCRIPTION
--             'Support is not required for routes that
--             match only a subset of possible source
```

```
--              addresses.'
--
--      OBJECT     t11FcRouteSrcMask
--      SYNTAX     FcAddressIdOrZero (SIZE (0))
--      DESCRIPTION
--              'Support is not required for routes that
--              match only a subset of possible source
--              addresses.'
--
--      OBJECT     t11FcRouteDestMask
--      DESCRIPTION
--              'Support is mandatory only for FSPF-generated
--              routes.  Since FSPF's definition generates
--              routes to a Domain_ID, the mask for all
--              FSPF-generated routes is 255.0.0.  Thus,
--              support is only required for 255.0.0.'
--
--      OBJECT     t11FcRouteInInterface
--      SYNTAX     InterfaceIndexOrZero (0)
--      DESCRIPTION
--              'Support for routes specific to particular
--              source interfaces is not required.'
          "

    MODULE  -- this module
        MANDATORY-GROUPS { t11FcRouteGroup }

        OBJECT     t11FcRouteIfDown
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

        OBJECT     t11FcRouteDomainId
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

        OBJECT     t11FcRouteMetric
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

        OBJECT     t11FcRouteType
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

        OBJECT     t11FcRouteStorageType
```

```
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

        OBJECT     t11FcRouteRowStatus
        SYNTAX     INTEGER { active(1) }
        MIN-ACCESS read-only
        DESCRIPTION
               "Write access is not required."

    ::= { t11FcRouteCompliances 1 }
t11FcRouteGroup  OBJECT-GROUP
    OBJECTS  { t11FcRouteFabricLastChange,
               t11FcRouteDomainId,
               t11FcRouteMetric,
               t11FcRouteType,
               t11FcRouteIfDown,
               t11FcRouteStorageType,
               t11FcRouteRowStatus
             }
    STATUS   current
    DESCRIPTION
           "A collection of objects for displaying and configuring
           routes."
    ::= { t11FcRouteGroups 1 }

END
```

7. Acknowledgements

This document was originally developed and approved by the INCITS Task Group T11.5 (http://www.t11.org) as the SM-RTM project. We wish to acknowledge the contributions and comments from the INCITS Technical Committee T11, including the following:

T11 Chair: Robert Snively, Brocade
T11 Vice Chair: Claudio DeSanti, Cisco Systems
T11.5 Chair: Roger Cummings, Symantec
T11.5 members, especially:
Ken Hirata, Emulex
Scott Kipp, McData
Elizabeth G. Rodriguez, Dot Hill

The document was subsequently approved by the IETF's IMSS Working Group, chaired by David Black (EMC Corporation). We also wish to acknowledge Bert Wijnen (Lucent Technologies), the IETF Area Director, for his review of the document.

8. IANA Considerations

The IANA has assigned a MIB OID for the T11-FC-ROUTE-MIB module under the appropriate subtree.

9. Security Considerations

There are several management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These objects and their sensitivity/vulnerability are:

```
t11FcRouteDomainId, t11FcRouteMetric, t11FcRouteType,
t11FcRouteIfDown, t11FcRouteRowStatus
   -- configure new routes and/or modify existing routes.
```

Such objects may be considered sensitive or vulnerable in some network environments. For example, the ability to change network topology or network speed may afford an attacker the ability to obtain better performance at the expense of other network users. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. The objects and their sensitivity/vulnerability are: the write-able objects listed above plus one other:

```
t11FcRouteLastChangeTime
   -- the time of the last routing table change.
```

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPSec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

It is RECOMMENDED that implementors consider the security features as provided by the SNMPv3 framework (see [RFC3410], section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is NOT RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

10. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

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